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(54) **Apparatus and method for pouring and levelling a concrete floor**

(57) The invention provides an apparatus for levelling a concrete floor poured on a support surface before full curing of the concrete takes place. The apparatus comprises levelling means connected to a frame for levelling the floor by discharging excess concrete, means for moving the levelling means in a direction of movement along the upper side of the concrete floor, and agitating means for agitating the poured concrete. The agitating means are positioned at the front of the levelling means, seen in the direction of movement, for subjecting the poured concrete to the successive actions of the agitating means and the levelling means.

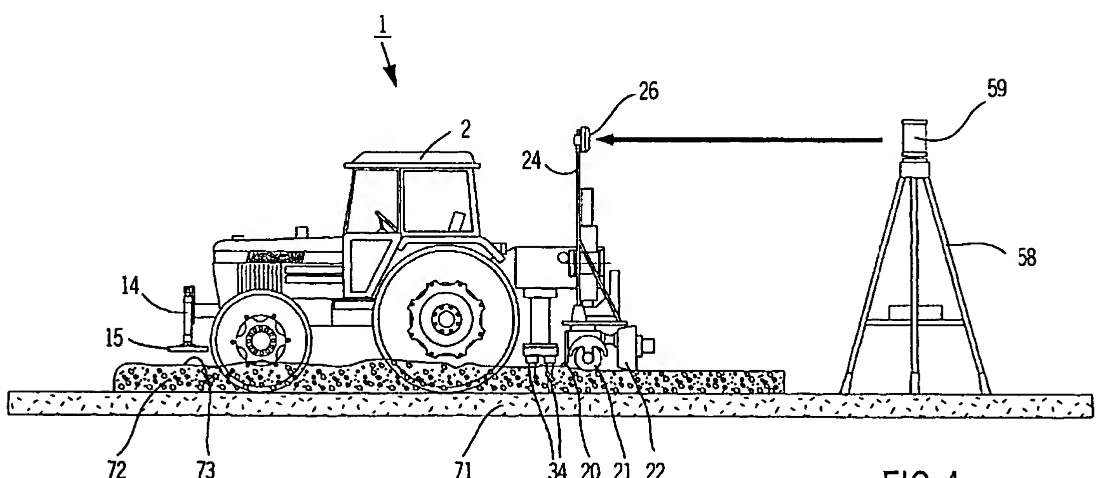

FIG.4

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Description

[0001] The invention relates to an apparatus for levelling a concrete floor poured on a support surface before full curing of the concrete takes place, which apparatus comprises levelling means connected to a frame for levelling the floor by discharging excess concrete, means for moving the levelling means in a direction of movement along the upper side of the concrete floor, and agitating means for agitating the poured concrete.

[0002] European patent application EP 0 953 683 A2 discloses an apparatus comprising a self-propelled vehicle including four wheels on rubber tyres. The vehicle is fitted with a turntable for pivoting an operating unit with respect to the chassis of the vehicle. A telescoping arm extends from said operating unit, on the end of which arm a mechanical unit intended for levelling a newly poured concrete floor is present. Said unit extends transversely to the main direction of the telescoping arm at the bottom side, it comprises a vibratory unit and a discharge screw disposed between said vibratory unit and the vehicle. When a newly poured concrete floor is to be flattened, the vehicle is placed on support plates so as to provide greater stability, as a result of which the rubber tyres are lifted off their support surface, after which the telescoping arm is extended and subsequently the mechanical unit is lowered. After activation of the vibratory unit and the discharge screw, the telescoping arm is telescoped back from this position, excess concrete is discharged laterally as a result of the rotation of the discharge screw, and the levelled concrete is densified by the vibratory screed.

[0003] The use of said apparatus has a large number of drawbacks. The levelling of the concrete floor takes place in a discontinuous manner, because the support plates on which the vehicle is supported during forward and backward movement of the telescoping arm must be retracted again after each reciprocating stroke of the telescoping arm, the vehicle must be moved forward over a distance equal to the width of the assembly and the support plates must be extended again. Moreover, it is difficult or even impossible in practice to ensure that the concrete that has been poured first is indeed levelled first, which would be ideal for technical reasons connected with the curing of the concrete. It is not possible to refrain from the use of the support plates and thus to accelerate the process, on the one hand because of the large tilting moment that acts on the vehicle because of the weight of the telescoping arm with the screeding unit present at the end thereof and on the other hand because of the springing nature of the rubber tyres that are used, which would stand in the way of the required stability of the system during the levelling of a poured concrete floor. In order to reduce the weight, and thus the tilting moment, the telescoping arm, or at least the mechanical unit connected thereto, is in part made of aluminium, which increases the cost of the apparatus.

[0004] Another significant drawback of the apparatus according to the prior art is the fact that it is only suitable for specific situation, in which a part of the support surface is kept free for the vehicle. It may be necessary to keep such a part of the support surface free intentionally and level it manually after pouring. This very fact makes such an apparatus less suitable or even altogether unsuitable for pouring a concrete road surface, for example on a viaduct. It is noted in this connection that the machine according to EP 0 953 683 A2 cannot be used for pouring a concrete floor on an inclined surface.

[0005] In addition to the limitations as regards the locations at which the levelling machine according to the prior art can be used, there are also major limitations with regard to the quality of the concrete to be poured. At least three parameters, which have been laid down in the form of standards and/or which are interdependent to a certain extent, give an idea of the said quality. With regard to the aforesaid standards, reference is made to the assessment guideline BRL 1801 as laid down by the "College van Deskundigen Betonmortel en Mortels" (Board of Experts on Concrete Mortar and Mortars) and confirmed by the Board of the Certification Institute BMC at Gouda, the Netherlands, which became operative on 1 October 1999, including the NEN standards, such as NEN 5950 and NEN 6720, to which reference is made in said assessment guideline.

[0006] In the first place, said parameters relate to the compression strength. By far the most common compression strength is 25 N/mm^2. Such concrete is indicated by the code B25.

[0007] The second parameter relates to the environmental class. The concrete is divided into the following main categories: mkI, mkII, mkIII, mkVb, mkVc, MkVd. The mkII class is by far the most common, it prescribes that the weight ratio between water and cement during the preparation of the concrete in the concrete mixing plant must not exceed 0.6. It will be understood that the viscosity of the concrete mortar being prepared will increase as said water-cement factor increases, making such concrete mortar easier to work. On the other hand, when the water-cement factor increases, the number of pores that remain after curing of the concrete as well as the dimensions thereof will be much larger. As a result, impurities, such as oil, can be absorbed in the concrete, whilst in addition the compression strength is adversely affected.

[0008] The third parameter is the consistency, which is expressed in the Z-measure. Said Z-measure expresses the extent to which a truncated cone of concrete mortar will shrink after an envelope is removed therefrom. The classes I - IV can be distinguished in this connection, class I exhibiting a relatively low consistency and class IV exhibiting a high consistency. As the consistency decreases, the compression strength will generally increases, but the concrete will become more difficult to work. Because of the resistance which the apparatus according to EP 0 953 683 A2 experiences upon working the concrete mortar, said apparatus is only ca-

pable of handling Z-measures that fall within class IV and, in some cases, within class III.

[0009] Usually a super plasticiser is added to the concrete mortar as an additive for influencing the aforesaid parameters. Also this system has its drawbacks, however, not in the last place because it makes the concrete mortar considerably more expensive. In addition, it has become apparent that the quality of such concrete mortar varies relatively widely in practice, and that there is an increased risk that any metalling present on the concrete floor will come loose. Successful levelling of a poured floor is only possible if the concrete has a relatively high consistency or, in other words, if the water content thereof is relatively high. One drawback of such concrete is the fact that it is subject to relatively large shrinkage stresses during the curing process, which may lead to shrinkage cracking, whilst in addition such types of concrete are only available for limited mechanical resistance values, making it necessary to incorporate a considerable amount of reinforcement in the concrete floor. In this connection it is possible to use mesh reinforcements or, alternatively, to add steel fibres to the concrete mortar. In the latter case it is usual to add 20-50 kg of reinforcing fibres to the concrete for every m^3 of cured concrete, in which connection it is noted that the aforesaid lower limit of 20 kg only obtains for floors which do not need to meet any special strength requirements. The addition of such types of reinforcement makes the pouring and levelling process more laborious and more costly.

[0010] An apparatus as referred to in the introduction is known from US patent No 1,720,377. Said patent discloses a machine for arranging paving materials. The machine comprises rake elements including two rows of forwardly inclined, downwardly extending pins. Said rows are capable of reciprocating, rotary movement about a horizontal axis extending parallel to the rows of pins near the upper side thereof. A screed is provided at the front side of the rake elements, so that the poured concrete will first be subjected to the action of the screed and only then to that of the rake elements. The machine disclosed in the aforesaid patents is not suitable for realising concrete floors having the degree of levelness that is required at present, precisely because of the action of the rake elements, which have a disturbing effect on the levelness of the road paving. Specifically for asphalt paving, the aforesaid US patent describes the arrangement of a screed behind the rake elements.

[0011] The object of the invention is to provide an apparatus as referred to in the introduction which, whether or not in a preferred embodiment thereof, provides a solution or at least a significant improvement as regards the aforesaid drawbacks of the prior art. In order to accomplish that objective, the invention is in the first place characterized in that said agitating means are positioned at the front of the levelling means, seen in the direction of movement, for subjecting the poured concrete to the successive actions of the agitating means and the levelling means. The use of agitating means thus arranged has major advantages. An important advantage in this connection is the fact that the agitating means make it possible to use concrete having a lower consistency level, for example a consistency level falling within class II, and thus, as a rule, higher mechanical resistance values, for example falling within class B40, and better environmental properties, for example falling within environmental class mkIII, as a result of which the amount of reinforcement in the concrete can be reduced and the risk of cracking is likewise reduced. Moreover, the agitating means, unlike the levelling means according to the prior art, are capable of levelling out any ruts that have formed in the newly poured concrete, as a result of which the levelled concrete can be smoothed yet by the levelling means. As a result of the energy that is introduced into the concrete by the agitating means, the concrete will briefly, for example for 30 seconds, behave more liquid than could be expected on the basis of its consistency. This enables the levelling means to perform their function better and more easily.

[0012] Preferably, the agitating means are connected to the frame for joint movement with the levelling means by the moving means. By using the frame as a binding factor for the levelling means and the agitating means, a constant spacing between the agitating means and the levelling means is obtained, seen in the direction of movement, the advantage of which, seen from a technical viewpoint, is that the concrete is subjected to the same succession of operations in time. This results in a very constant quality of the concrete floor.

[0013] In a very advantageous embodiment, the moving means comprise a vehicle which is movable in the direction of movement, to which vehicle the frame is attached. The reciprocating telescoping arm according to the prior art has thus been substituted for a movable vehicle, making it possible to realise a continuous process rather than a discontinuous process. It is noted in this connection that it is the agitating means that make it possible for the vehicle to move over the support surface and through the newly poured concrete. The ruts thus being formed are levelled again by the agitating means, which distribute the poured concrete evenly before the concrete is subjected to the action of the levelling means.

[0014] In order to obtain greater stability, the vehicle is preferably fitted with steel wheels. The use of such steel wheels with apparatuses according to the prior art would have major advantages as well, even if no agitating means were used.

[0015] In order to prevent the formation of ruts as much as possible, the vehicle is preferably fitted with wheels having a discontinuous bearing surface.

[0016] Preferably, the agitating means comprise stirring means for effecting a stirring movement of the pins. A stirring movement, with the pins moving perpendicularly to their longitudinal direction, is very suitable for introducing energy into the poured concrete, resulting in

the required densification of the poured concrete.

[0017] A very practical embodiment is obtained if the bearing surface comprises bars. Spaces are left open between the bars, as a result of which part of the concrete mortar is left relatively unaffected upon passage of a wheel therethrough.

[0018] Within this framework it is furthermore advantageous if the vehicle is fitted with wheels whose sides are substantially open, at least at the outer circumference thereof. Also in this case the positive advantage of this feature is that the extent to which ruts are formed by the wheels of the vehicle remains limited.

[0019] A very advantageous and practical embodiment is obtained if the agitating means comprise substantially downwardly extending pins. Such pins may be circular, square or otherwise rectangular in cross-section, and preferably they have a conical end.

[0020] Preferably, the agitating means comprise stirring means for effecting a stirring movement of the pins. Typical of the stirring movement is the fact that said stirring movement is directed perpendicularly, or at least substantially perpendicularly, to the longitudinal direction of the pins.

[0021] A very efficient manner of agitation can be effected if the stirring means are provided with translating means for causing pins to translate in a direction substantially perpendicularly to the direction of movement. It will be understood that, absolutely speaking, such pins also comprise a motion component in the direction of movement during the movement of the stirring means in the direction of movement. Such pins may be arranged in a row in the form of a rake, for example.

[0022] In order to increase the agitation capacity, at least a number of the pins are arranged in two rows positioned one behind the other, seen in the direction of movement, which rows extend substantially perpendicularly to the direction of movement and which can be translated in opposite phase by the translating means.

[0023] A constructionally advantageous and simple embodiment is obtained if the two rows are interconnected by means of at least one connection with which the rows are pivotally connected, which connection is rotatable about a vertical axis extending between the two rows.

[0024] Alternatively, or in addition to translating pins, the stirring means may according to one preferred embodiment be provided with rotating means for rotating at least a number of the pins about at least one substantially vertical axis. Also such stirring means are easy to construct. In order to enhance the effectiveness and capacity as regards the agitating capacity, the pins are preferably rotatable in groups by the rotating means, so that a number of pins are present for each vertical axis.

[0025] In order to achieve that not only the upper part but also the lower part of poured concrete directly above the support surface is subjected to the action of the agitating means, the lower ends of the pins are spaced from the support surface by a distance of maximally 8 cm, preferably maximally 5 cm. It is noted that 15 cm is a usual layer thickness for the concrete.

[0026] Preferably, the agitating means comprise vibrating means for effecting a vibrating movement of the pins, possibly in combination with the stirring means as described above. Vibration, too, is a very suitable manner of introducing sufficient energy into poured concrete by mechanical interaction between the pins and the poured concrete so as to have the necessary densification of the poured concrete take place, even in the case of relatively dense types of concrete. In order to disturb the poured concrete as little as possible, the vibrating means are preferably so arranged as to cause the pins to vibrate substantially in the longitudinal direction of the pins.

[0027] Furthermore, the vibrating means are preferably arranged for causing the pins to vibrate at a frequency of at least 1,000 Hz, preferably at least 10,000 Hz, as a result of which the magnitude of the stroke of the vibration can be limited.

[0028] The vibrating means are preferably arranged for causing the ends of the ends to vibrate with a stroke of maximally 5 cm, preferably maximally 1 cm.

[0029] According to a highly advantageous embodiment of the invention, the levelling means comprise displacing means for positive displacement of at least part of the excess of the poured concrete perpendicularly to the direction of movement. This is to prevent an objectionably large amount of concrete being moved ahead by the apparatus, or the apparatus following the contours formed by the excess concrete, as it were, which would lead to an insufficient degree of levelness of the poured concrete.

[0030] Furthermore, the levelling means preferably comprise a vibrating element which is capable of vibrating movement against the upper side of the poured concrete, in a direction perpendicularly to the upper side of the poured concrete.

[0031] It is very advantageous in this connection if the displacing means are disposed between the vibrating element and the agitating means, so that the poured concrete is subjected to the successive actions of the agitating means, the displacing means and the vibrating elements.

[0032] In particular if the support surface comprises unevennesses, there is a risk of the levelling means assuming an oblique position, which might lead to a sloping concrete floor or a floor which is not level. In order to prevent this, one preferred embodiment of the invention comprises sensor means for determining the spatial orientation and the vertical position of the levelling means and delivering information with regard thereto to a control system, which control system delivers control signals to adjusting means for adjusting the levelling means in vertical direction with respect to the frame so as to maintain the correct orientation and vertical position of the levelling system.

[0033] For certain types of floors it may be advanta-

geous if the apparatus comprises distributing means for distributing additives over the levelled floor, which distributing means are connected to the frame at the rear side of the levelling means, seen in the direction of movement. Such additives may be quartz or cement powder, for example, intended for making the top layer of the concrete floor harder. According to the prior art, such additives are manually strewn over the floor surface in those places where the expert considers this necessary. This is connected with the relatively lack of constancy as regards the quality of the concrete floors poured in accordance with the prior art. The apparatus according to the invention makes it possible, however, to form concrete floors whose quality is constant to such a degree that such additives can be distributed evenly over the surface.

[0034] A very advantageous embodiment of such distributing means is obtained if the distributing means comprise a reservoir for the additives which has an open bottom side which is closed by a distributor extending substantially across the width of the levelling means, which distributor is rotatable about a horizontal axis for the metered passage of additives.

[0035] An extremely even distribution of the additives is obtained if chambers for containing the additives are arranged on the outer surface of the distributor. If the chambers are present at the upper side of the distributor, additives will be introduced into the chambers at that location, which additives will be released again after rotation through 180° and which will thus be distributed over the poured and levelled concrete floor.

[0036] The invention also relates to a method for pouring and levelling a concrete floor, using an apparatus according to the invention as described above. The method according to the invention is characterized by the successive steps of

- A pouring concrete on a support surface,
- B evenly distributing the concrete that has been poured on the support surface, using the agitating means,
- C levelling the evenly distributed concrete, using the levelling means,
- D allowing the levelled concrete to cure.

[0037] The advantages obtained by using such a method have already been explained in the description of the apparatus according to the invention.

[0038] A unique feature of a method as described in the above paragraph is the fact that it is possible to level and/or homogenise poured concrete exhibiting relatively large unevennesses and/or degrees of denseness. Such unevennesses might be caused by a vehicle which moves through the poured concrete, for example, thus moving the agitating means and the levelling means along the poured concrete and leaving ruts in the poured concrete. In principle, the formation of such ruts is no longer an insurmountable drawback thanks to the present invention, so that very advantageous embodiments of the method according to the invention become possible. Consequently, one preferred embodiment of the method according to the invention is characterized by the use of an apparatus whose moving means comprise a vehicle being movable in the direction of movement, to which the frame is attached, which vehicle drives through the concrete that has been poured in accordance with step A. In principle it is thus possible to form a strip of concrete floor of infinite length in a continuous manner.

[0039] The advantages obtained by using the method according to the invention are even greater if concrete having a Z-measure of maximally 120 mm, preferably maximally 100 mm, is used for carrying out step A. in this connection reference is made to the afore-cited assessment guideline, including the standards that are mentioned therein.

[0040] The same advantages applies if concrete having a compression strength of at least 35 N/mm^2, preferably at least 55 N/mm^2, is used for carrying out step A. Also in this connection reference is made to the afore-cited assessment guideline.

[0041] The method according to the invention has furthermore made it possible to incorporate a reduced amount of reinforcement in the concrete while retaining the same level of strength. Consequently, one preferred embodiment of the method according to the invention is characterized in that concrete containing an amount of reinforcement of maximally 30 kg/m^3 of concrete, preferably maximally 20 kg/m^3 of concrete, is used for carrying out step A.

[0042] In extreme situations this may mean that it is decided not to use any reinforcement in the concrete at all, in which case the method would be characterized in that the concrete is free from reinforcement.

[0043] The apparatus and method according to the invention will be explained in more detail hereinafter by means of two preferred embodiments of the invention. In the description, reference will be made to the following Figures:

Figure 1 shows a first embodiment of an apparatus according to the invention;
Figure 2 is a top plan view of Figure 1;
Figure 3 shows the first embodiment during operation;
Figure 4 shows the situation of Figure 3 in side elevation and partial cross-sectional view;
Figure 5 shows the stirring means;
Figures 6a and 6b show the stirring means in top plan view in two extreme positions thereof;
Figure 7 shows an alternative embodiment of the stirring means in bottom plan view;
Figure 8 schematically shows the method according to the invention carried out with the first preferred embodiment;
Figure 9 shows a second embodiment of an appa-

ratus according to the invention;

Figure 10a shows, partially in sectional view, a distributor for use with the second embodiment; and

Figure 10b shows the end of said distributor.

[0044] Figures 1 and 2 show a first preferred embodiment of the apparatus according to the invention in perspective view and in top plan view, respectively. The apparatus is a machine 1 substantially consisting of an adapted tractor 2 and a power-driven levelling unit 3. The power-driven levelling unit 3 is connected to the tractor 2 by means of a frame 4 which is rigidly connected to the tractor 2.

[0045] The tractor 2 has been adapted, in the sense that it is fitted with a continuously variable driving gear, which enables constant travelling speeds from 0 to 250 m per hour. In this particular case, the driving gear is a hydrostatic driving gear. Another striking adaptation is formed by the front wheels 5a, 5b and the rear wheels 6a, 6b. Said wheels 5a, 5b, 6a, 6b are not fitted with the standard rubber tires, which have been substituted for steel units. The two front wheels are built up of steel rims 7a, 7b, 7c. Arranged between two neighbouring rims 7a, 7b, 7c are staggered bars 8a, 8b interconnecting the rims 7a, 7b, 7c, which are oriented in V-shape relative to each other. Present within the rims 7a, 7b, 7c of each wheel 5a, 5b is a connecting disc 9, via which connecting disc 9 the front wheel 5a, 5b in question is coupled to the front axle 10 of the tractor 2. The construction of the rear wheels 6a, 6b, which are spaced further apart and which have a larger diameter than the front wheels 5a, 5b, is comparable to that of the front wheels 5a, 5b, with this difference that the rear wheels 6a, 6b comprise four rims 11a, 11b, 11c, 11d and thus three rings of bars 12a, 12b, 12c. The rear wheels 6a, 6b, too, comprise a connecting disc 13 by means of which the rear wheels 6a, 6b are coupled to the rear axle. As regards the adaptations of the tractor 2, it is furthermore relevant to draw attention to the presence of three jacks, by means of which the front wheels 5a, 5b and the rear wheels 6a, 6b can be lifted from their support surface. In Figure 2 the front jack 14 including the foot pad 15 can be distinguished, whilst the location of the two rear jacks under the chassis is of the tractor 2 is indicated by the circles 16, 17.

[0046] The power-driven levelling unit 13 comprises a screeding unit 18 and a stirring unit 19 positioned between the adapted tractor 2 and the screeding unit 18. The screeding unit 18 may be considered to be known at least from European patent applications EP 376 692 A2 and EP 953 683 A2, to which reference is made for a detailed description. The screeding unit 18 will only be described herein insofar as is necessary within the framework of the invention. The screeding unit 18 comprises a steel screed board 20, an Archimedean screw 21 and a vibrating beam 22. The Archimedean screw 21 is screened at its upper side by a semicylindrical guard 23. The screed board 20, the Archimedean screw 21 and the vibrating beam 22 extend perpendicularly to the normal direction of movement of the tractor 2 as indicated by the arrow 23, over a width of about 330 cm. The screeding unit 18 further comprises two uprights 24, 25, on the upper sides of which laser beam receivers 26, 27 are mounted.

[0047] Two U-shaped brackets 28, 29 are present at the rear side of the frame 4, between the legs of which two hydraulic cylinders 30, 31 are connected to the frame 4. At the bottom side of the piston rods associated with the hydraulic cylinders 30, 31, the screeding unit 18 is connected to the hydraulic cylinders 30, 31, and thus also to the frame 4, in two places. The screeding unit 18 can be moved in vertical direction through operation of the hydraulic cylinders 30, 31.

[0048] The stirring unit 19 is separately shown in Figures 5, 6a and 6b. The stirring unit 19 consists of two rake elements 32, 33 positioned one behind the other, seen in the direction of movement as indicated by the arrow 23, which rake elements extend parallel to each other and perpendicularly to said direction of movement. Each rake element 32, 33 comprises a steel strip 34, from which twenty steel pins 34 extend vertically downwards. The rake elements 32 and 33 are interconnected by means of two connecting beams 35, 36, at the two ends of which pivot pins 37, 38 and 39, 40, respectively, are present, which enable pivoting movement of the connecting beams 35, 36 with respect to the rake elements 32, 33. The two connecting beams 35, 36 are in turn interconnected at their centres by means of a main beam 41, on the ends of which vertical drive shafts 42, 43 are mounted. The drive shafts 42, 43 are driven in an oscillating manner by driving means (not shown). Said driving means comprise a crankshaft-connecting rod mechanism, which is driven by the usual outgoing drive shaft of the tractor 2. As a result, the two rake elements 32, 33 move between the two extreme positions that are shown in Figures 6a and 6b. This movement can be described essentially as being a translating movement.

[0049] Figures 3 and 4 slightly schematically show the use of the machine 1. The starting point is the intention to form a rectangular concrete floor 51, whose external dimensions correspond to those of a rectangle. The rectangular floor 51 is built up of four strips 52, 53, 54, 55, each having a width 56. Said width 56 corresponds to the width of the screeding unit 18 and the matching width of the stirring unit 19. The strip 52 has already been subjected to the action of the machine 1, whilst in Figure 3 the machine 1 has just started to work the second strip 53. The tractor 2 drives through a poured strip of concrete mortar 57 with its open steel wheels. The concrete in the strip behind the power-driven levelling unit 3 is level and ready for further curing, whereas the concrete located ahead of the tractor 2 is still relatively loose. It will be apparent that the passage of the tractor 2 through said relatively loose concrete mortar will initially make said concrete mortar even looser, because of the ruts

that are formed by the front and rear wheels of the tractor 2. As a matter of fact, the extent to which ruts are formed will be limited in comparison with the situation that would arise if rubber wheels were used, because of the open nature of the wheels as described above.

[0050] Outside the rectangular floor 51, a laser beam transmitter 59 is mounted on a tripod 58, which transmitter transmits laser beams in an absolutely horizontal plane as indicated by the arrows 60, 61. Said laser beams are registered by means of the laser beam receivers 26, 27. If the vertical positions at which the laser beams are registered by the laser beam receivers 26, 27 do not correspond to a vertical position corresponding to a desired vertical position of the upper side of the concrete floor, one hydraulic cylinder 30, 31, or both, will be driven by a control system (not shown) to correct the vertical position of the laser beam receivers 26, 27 and thus adapt the vertical position and/or the orientation of the screeding unit 18 as a whole, as a result of which the desired or required levelness of the concrete floor can be achieved. The jacks that have been described above are used advantageously for setting reference points for the laser beams so as to calibrate the laser control system before the operations are started. Although this possibility is not excluded within the framework of the invention, vertical movement of the stirring unit 19 on the basis of the control signals transferred by the laser beam receivers 26, 27 does not take place.

[0051] Figures 4 and 8 visualise the operation of the various parts of the machine 1 according to the invention. A strip of concrete mortar 72 has been poured on a support surface 71 formed by a sand or rubble bed, which may or may not be stabilised. Directly after being poured, the concrete mortar 72 has an uneven upper surface 73. The tractor 2 drives through the poured concrete mortar 72, its wheels resting on the rubble bed 71, causing the concrete mortar 72 to become even more uneven, because the front wheels 5a, are 5b and the rear wheels 6a, 6b form ruts 74 and 75, respectively, in the concrete mortar 72. After the passage of the tractor 2, the concrete mortar 72 is subjected to the action of the stirring unit 19, more specifically to the translating, reciprocating movement of the pins 34. As a result, the concrete mortar 72 is distributed evenly again, so that the concrete mortar is smoothed and the ruts 74, 75 will disappear. The energy that is put into the concrete mortar 72 as a result of the movement of the pins 34 will cause the concrete mortar 72 to behave more liquid than would be expected on the basis of its characteristics without the addition of said energy. Since the bottom side of the pins 34 is spaced from the upper surface of the support surface 71 by no more than about 2 - 3 cm, all concrete mortar is subjected to the action of the pins, which action is not limited to the upper layer of the concrete mortar 72. Although the stirring unit 19 effects a certain levelling of the concrete mortar, the upper surface of the concrete mortar 72 does not have the required degree of levelness yet. For this purpose the screeding unit 18 is provided, which in fact operates in three stages. During the first stage, a first levelling of the concrete mortar 72 is effected by means of the screed board 20. Then the Archimedean screw 21, whose lowermost point is positioned about 10 mm below the lower edge of the screed board 20, effects a second levelling by moving excess concrete mortar in lateral direction to the next strip, as indicated by the arrows 76. Finally, the vibrating beam 22 causes the concrete mortar 72, which has thus been levelled in two stages, to be mechanically densified in vertical direction, thus providing a very level upper surface having the required degree of levelness and being ready for curing.

[0052] The use of the stirring unit 19 has major advantages. Thus, the stirring unit 19 makes it possible for the tractor 2 to move through the concrete mortar that has just been poured, making it possible in principle to form concrete floor strips of infinite length. In addition to that, the use of the stirring unit 19 makes it possible to work concrete having a relatively low consistency, as a result of which excellent strength properties, for example in accordance with class B45, and excellent environmental properties, for example in accordance with class mkIII, can be obtained. The possibility to work concrete having high mechanical strength values makes it possible to achieve a significant reduction of the amount of reinforcing steel that is used in the concrete, or even to refrain from the use thereof altogether.

[0053] within the framework of the invention it is also possible to use a vibrating unit instead of a stirring unit 19. Said vibrating unit might comprise a rake element similar to the rake elements 32 and 33, for example. Instead of making a stirring movement, said rake element might carry out a vibrating or pulsating vertical movement, however, for example at a frequency of 15,000 - 25,000 Hz, with a vibrating stroke of 1 cm, in which at least the bottom sides of the pins are in mechanical interaction with the poured concrete mortar 72.

[0054] Figure 7 shows an alternative embodiment of a stirring unit 81. In this embodiment, two pins 82 are mounted on a circular disc 83 which is rotatable about a vertical axis through its centre. Said rotation may or may not take place in a reciprocating manner. A row of, for example, twenty such discs 83 is present on a beam 84 which extends perpendicularly to the direction of movement of the tractor, so that a width corresponding to that of the stirring unit 19 is covered. It stands to reason that it is also possible to use more than two pins 82 for each disc 83. It is also conceivable to additionally impart a vibrating movement to the beam 84 in the longitudinal direction thereof.

[0055] Figure 9 shows a second embodiment of an apparatus according to the invention, which is only different from the first embodiment in that this second embodiment comprises a distribution unit 91 at the rear side of the screeding unit 18. With some types of surfaces, for example road surfaces, it is necessary to add additives, such as quartz and cement, to the upper surface

of the concrete floor shortly after the pouring and levelling thereof. This can take place in a simple manner by means of the distribution unit 91. The distribution unit 91, which is substantially made up of a container 92 of funnel-shaped cross-section, is fixed to the frame 4 in a manner which is not shown. The desired additives can be introduced into the container 92 from the open upper side thereof, which can be closed by means of an open framework 93. Present at the bottom of the container is a rotating horizontal shaft 94, which is passed through an undulating strip 95, as it were. As a result of the rotation of the shaft 94, the additives with which the container 92 is filled will be stirred by the undulating strip 95. The container 92 is closed at its bottom side by a metering star wheel 96 consisting of a shaft 97 fitted with a number of radial strips 98 extending along the length of the shaft 97. Chambers 99 are thus formed between adjacent strips 98. C-shaped closing surfaces 100, 101 are provided on the outside of the strips 98. An outlet opening 102 extending along the length of the shaft 97 is formed between the lower edges of the closing surfaces 100, 101. The width of the outlet opening 102 and the spacing and the height of the strips 98 has been selected so that maximally one strip extends within the open bottom side of the container 92. Additives are introduced into a chamber 99 in an upper position thereof, and after a rotation through 180 degrees of the shaft 97, said additives are delivered via the outlet opening 102, so that they will fall on the newly poured and levelled concrete. A driving gear 103 for the required rotation of the shaft 94 and the shaft 97 is provided on the outside of the container 92, which driving gear rotates both the shaft 94 and the shaft 97 via a suitable transmission 104. The associated control system provides infinitely variable operation of the driving mechanism 103 in dependence on the speed of movement of the tractor 2, so that a constant amount of additives per unit area is spread over the concrete floor independently of the speed of movement of the tractor 2.

Claims

1. An apparatus for levelling a concrete floor poured on a support surface before full curing of the concrete takes place, which apparatus comprises levelling means connected to a frame for levelling the floor by discharging excess concrete, means for moving the levelling means in a direction of movement along the upper side of the concrete floor, and agitating means for agitating the poured concrete, **characterized in that** said agitating means are positioned at the front of the levelling means, seen in the direction of movement, for subjecting the poured concrete to the successive actions of the agitating means and the levelling means.

2. An apparatus according to claim 1, **characterized in that** the agitating means are connected to the frame for joint movement with the levelling means by the moving means.

3. An apparatus according to claim 1 or 2, **characterized in that** the moving means comprise a vehicle which is movable in the direction of movement, to which vehicle the frame is attached.

4. An apparatus according to claim 3, **characterized in that** the vehicle is fitted with steel wheels.

5. An apparatus according to claim 3 or 4, **characterized in that** the vehicle is fitted with wheels having a discontinuous bearing surface.

6. An apparatus according to claim 5, **characterized in that** said bearing surface comprises bars.

7. An apparatus according to any one of the claims 3 - 6, **characterized in that** the vehicle is fitted with wheels whose sides are substantially open, at least at the outer circumference thereof.

8. An apparatus according to any one of the preceding claims, **characterized in that** the agitating means comprise substantially downwardly extending pins.

9. An apparatus according to claim 8, **characterized in that** the agitating means comprise stirring means for effecting a stirring movement of the pins.

10. An apparatus according to claim 9, **characterized in that** the stirring means are provided with translating means for causing pins to translate in a direction substantially perpendicularly to the direction of movement.

11. An apparatus according to claim 10, **characterized in that** at least a number of the pins are arranged in two rows positioned one behind the other, seen in the direction of movement, which rows extend substantially perpendicularly to the direction of movement and which can be translated in opposite phase by the translating means.

12. An apparatus according to claim 11, **characterized in that** the two rows are interconnected by means of at least one connection with which the rows are pivotally connected, which connection is rotatable about a vertical axis extending between the two rows.

13. An apparatus according to any one of the claims 8 - 12, **characterized in that** the stirring means are provided with rotating means for rotating at least a number of the pins about at least one substantially vertical axis.

14. An apparatus according to claim 13, **characterized in that** pins can be rotated in groups by the rotating means about said at least one substantially vertical axis.

15. An apparatus according to any one of the claims 8 - 14, **characterized in that** the lower ends of the pins are spaced from the support surface by a distance of maximally 8 cm, preferably maximally 5 cm.

16. An apparatus according to any one of the claims 8 - 15, **characterized in that** the agitating means comprise vibrating means for effecting a vibrating movement of the pins.

17. An apparatus according to claim 16, **characterized in that** the vibrating means arranged for causing the pins to vibrate substantially in the longitudinal direction of the pins.

18. An apparatus according to claim 16 or 17, **characterized in that** the vibrating means are arranged for causing the pins to vibrate at a frequency of at least 1,000 Hz, preferably at least 10,000 Hz.

19. An apparatus according to claim 16, 17 or 18, **characterized in that** the vibrating means are arranged for causing the ends of the ends to vibrate with a stroke of maximally 5 cm, preferably maximally 1 cm.

20. An apparatus according to any one of the preceding claims, **characterized in that** the levelling means comprise displacing means for positive displacement of at least part of the excess of the poured concrete perpendicularly to the direction of movement.

21. An apparatus according to claim 20, **characterized in that** said displacing means comprise an Archimedean screw, which is rotatable about an axis extending parallel to the upper side of the poured concrete and perpendicularly to the direction of movement.

22. An apparatus according to any one of the preceding claims, **characterized in that** the levelling means comprise a vibrating element which is capable of vibrating movement against the upper side of the poured concrete, in a direction perpendicularly to the upper side of the poured concrete.

23. An apparatus according to claim 20 or 21 on the one hand and claim 22 on the other hand, **characterized in that** said displacing means are disposed between the vibrating element and the agitating means.

24. An apparatus according to any one of the preceding claims, **characterized by** sensor means for determining the spatial orientation and the vertical position of the levelling means and delivering information with regard thereto to a control system, which control system delivers control signals to adjusting means for adjusting the levelling means in vertical direction with respect to the frame so as to maintain the correct orientation and vertical position of the levelling system.

25. An apparatus according to any one of the preceding claims, **characterized by** distributing means for distributing additives over the levelled floor, which distributing means are connected to the frame at the rear side of the levelling means, seen in the direction of movement.

26. An apparatus according to claim 25, **characterized in that** the distributing means comprise a reservoir for the additives which has an open bottom side which is closed by a distributor extending substantially across the width of the levelling means, which distributor is rotatable about a horizontal axis for the metered passage of additives.

27. An apparatus according to claim 26, **characterized in that** chambers for containing the additives are arranged on the outer surface of the distributor.

28. A method for pouring and the levelling a concrete floor, using an apparatus according to any one of the claims 1 - 27, **characterized by** the successive steps of

A pouring concrete on a support surface,
B evenly distributing the concrete that has been poured on the support surface, using the agitating means,
C levelling the evenly distributed concrete, using the levelling means,
D allowing the levelled concrete to cure.

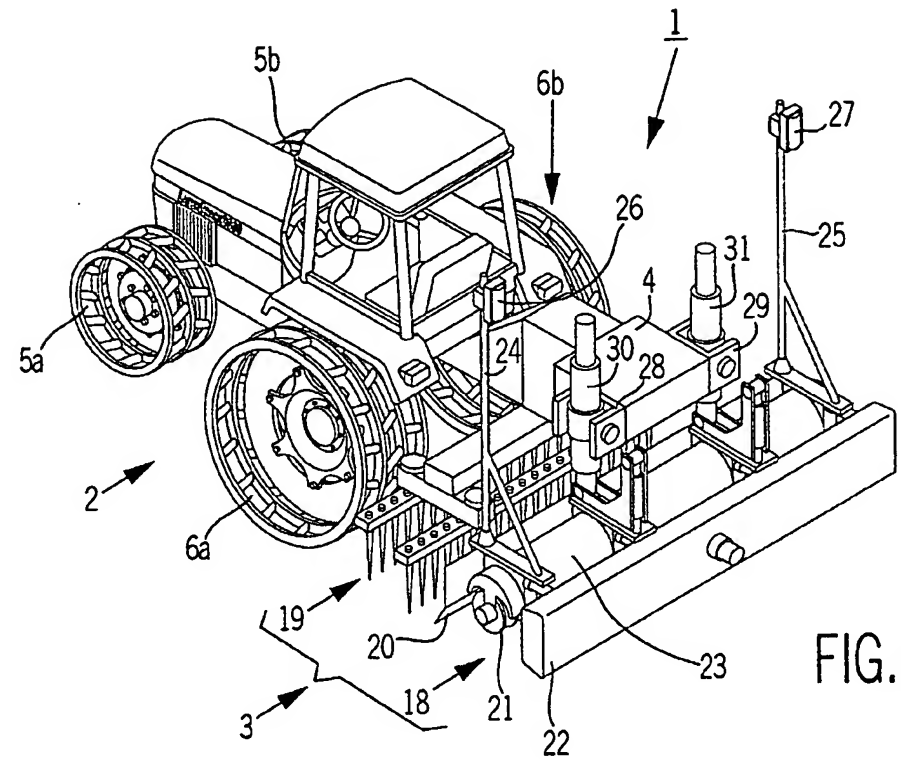
29. A method according to claim 28, **characterized by** the use of an apparatus according to any one of the claims 3 - 27, wherein the vehicle drives through the concrete that has been poured in accordance with step A.

30. A method according to claim 28 or 29, **characterized in that** concrete having a Z-measure of maximally 120 mm, preferably maximally 100 mm, is used for carrying out step A.

31. A method according to claim 28, 29 or 30, **characterized in that** concrete having a compression strength of at least 35 N/mm^2, preferably at least 55 N/mm^2, is used for carrying out step A.

32. A method according to any one of the claims 28 - 31, **characterized in that** concrete containing an amount of reinforcement of maximally 30 kg/m^3 of concrete, preferably maximally 20 kg/m^3 of concrete, is used for carrying out step A.

33. A method according to claim 32, **characterized in that** the concrete is free from reinforcement.



1
5b
6b
27
26
25
31
4
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30
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5a
2
6a
19
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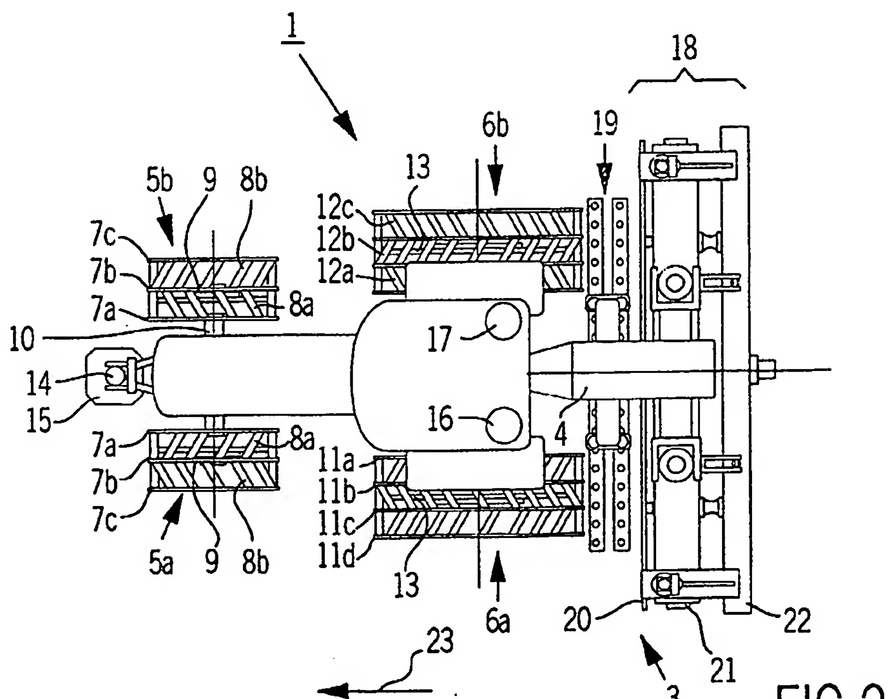
18
21
3
22

FIG.1



1
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15
16
4
7a
8a
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3
21

FIG.2

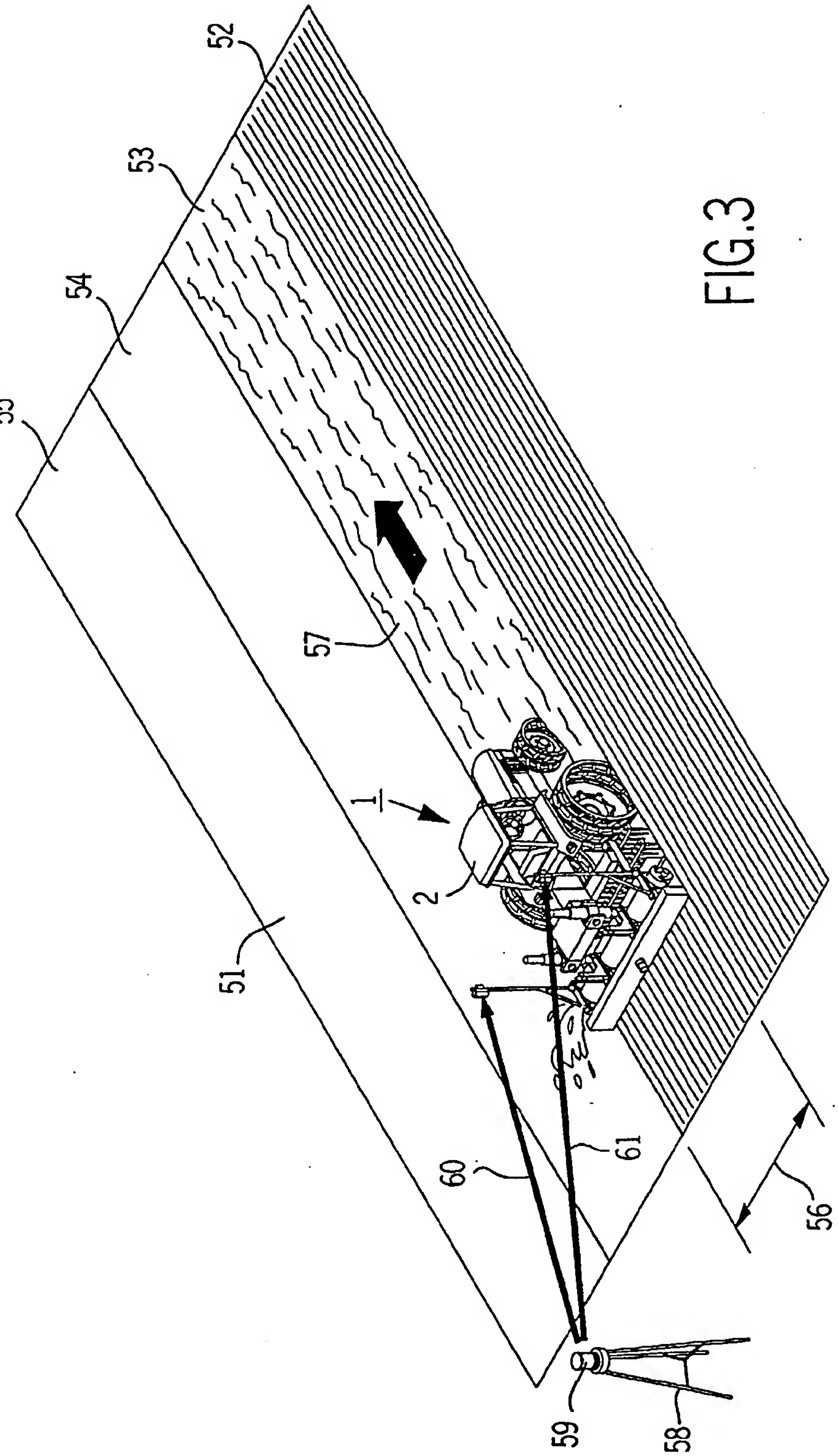

FIG.3

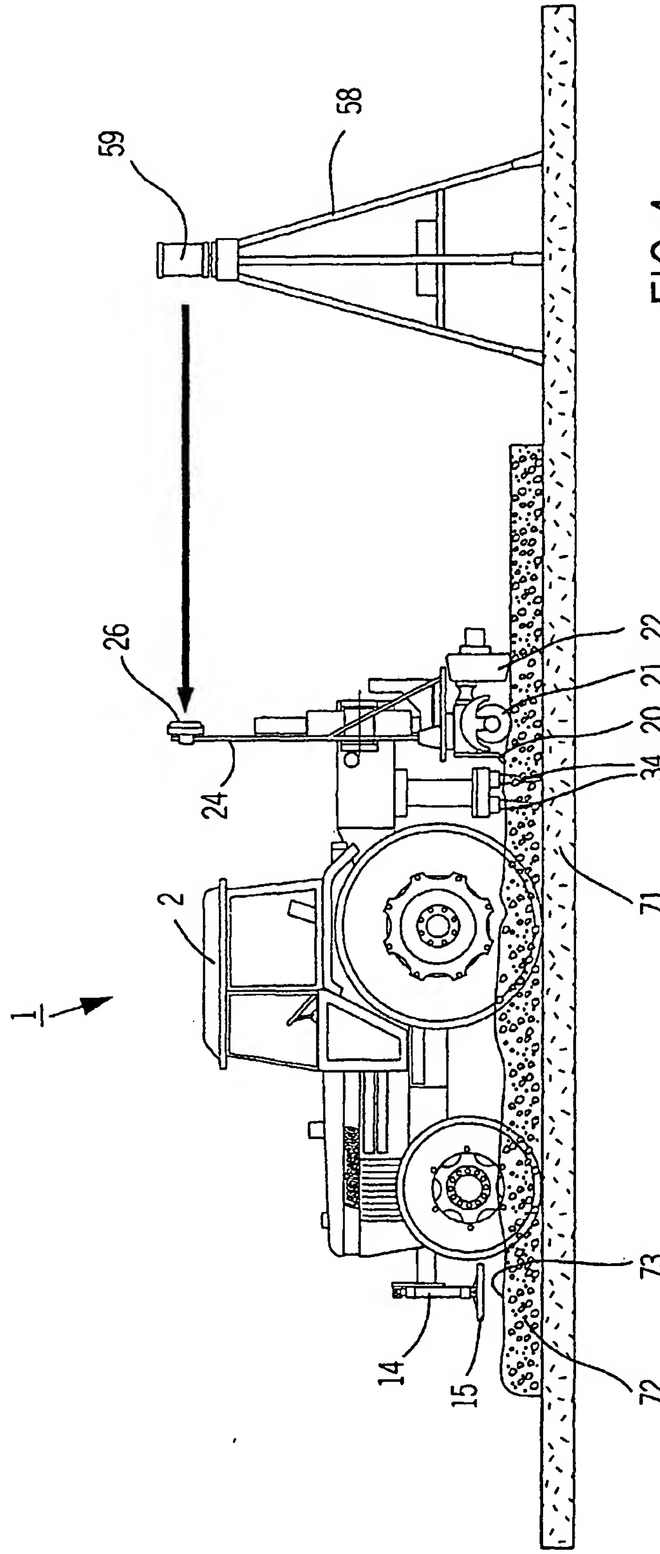

FIG.4

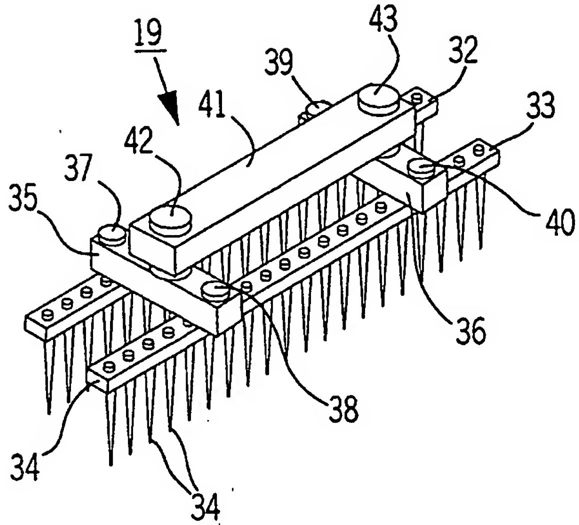

FIG.5

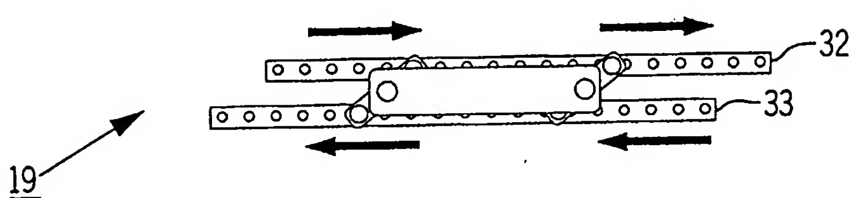

FIG.6A

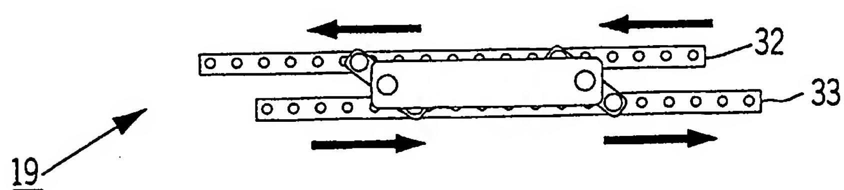

FIG.6B

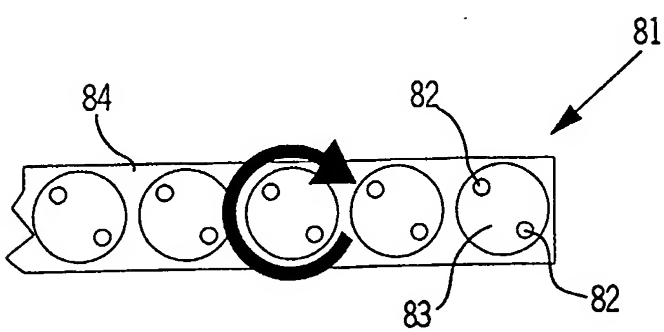

FIG.7

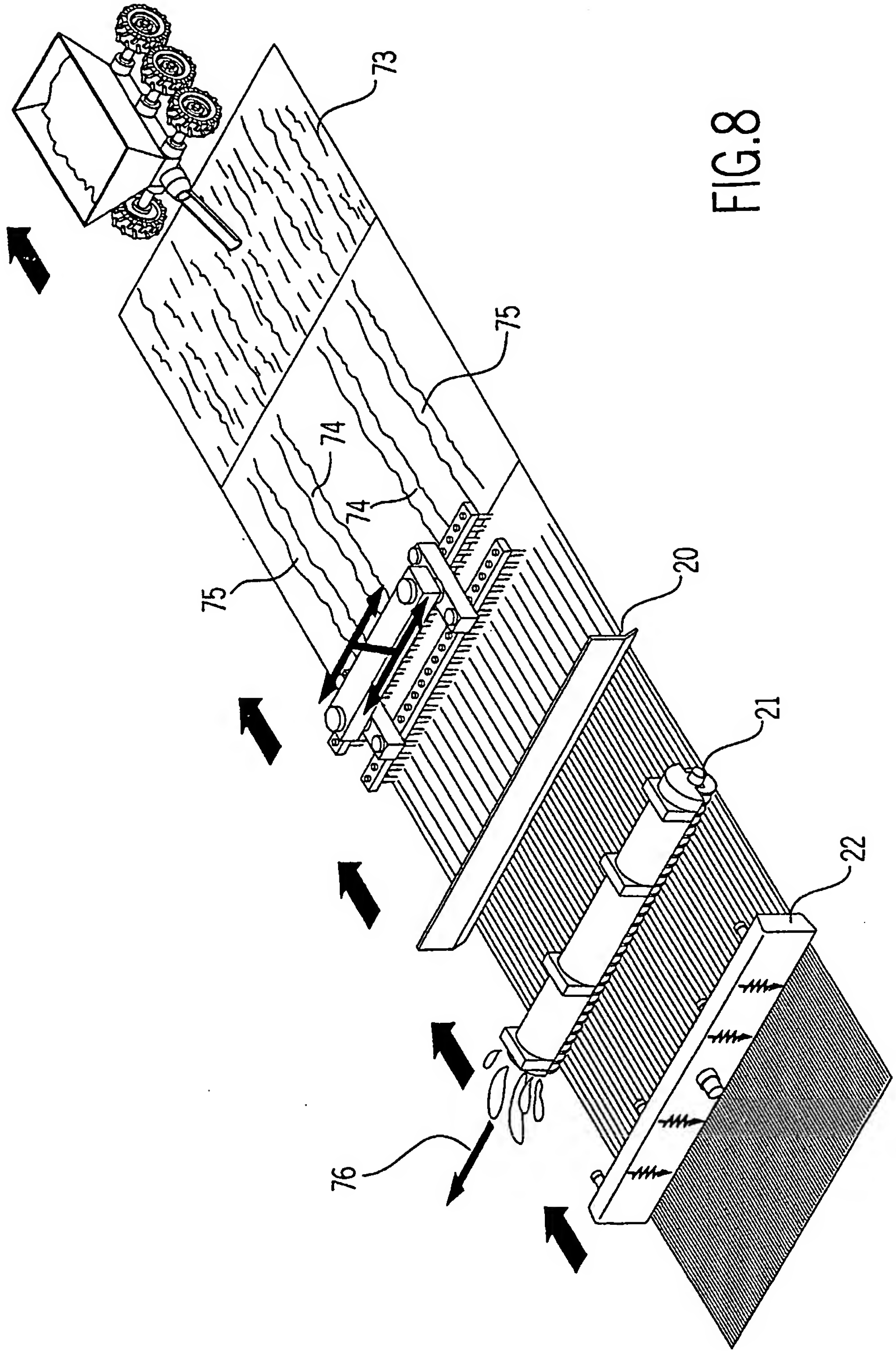

FIG.8

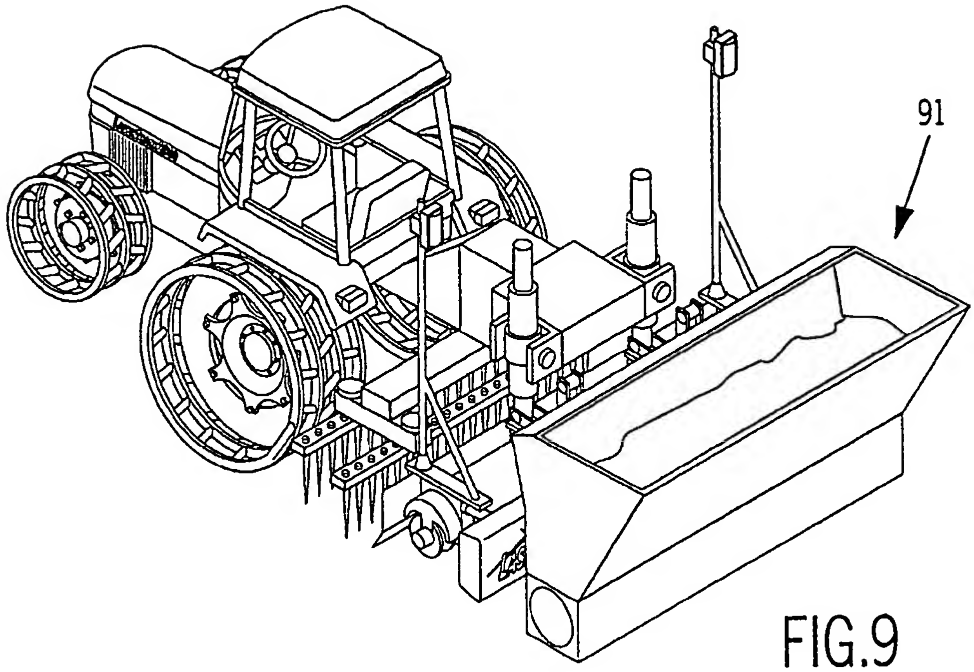

FIG.9

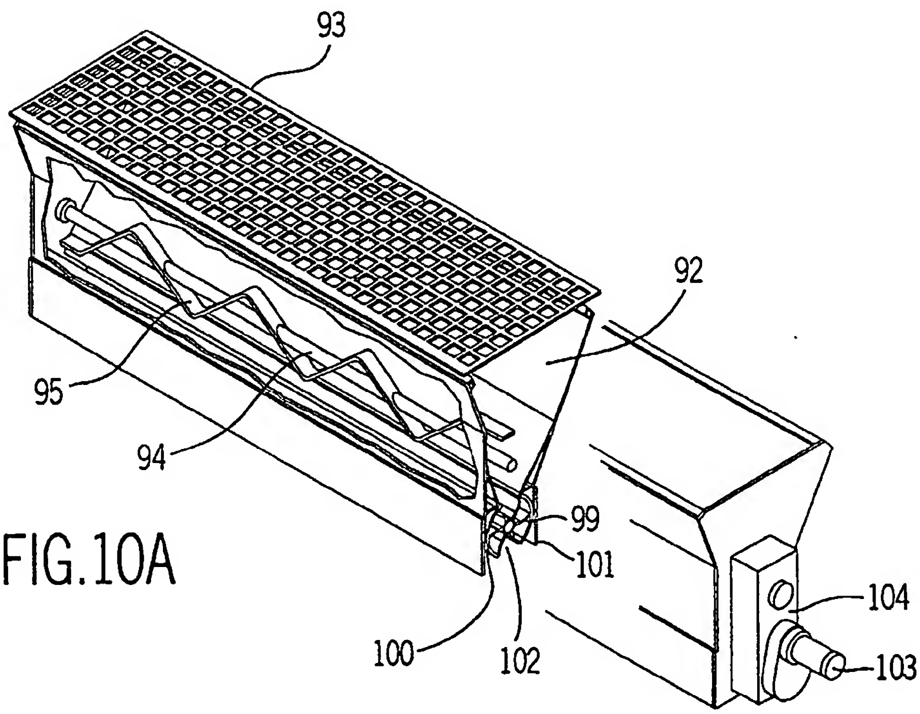

FIG.10A

FIG.10B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 07 9784

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 February 2003	Dijkstra, G

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